THE GLANDULAR HAIRS OF BRASENIA PELTATA PURSH.

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The thick coating of jelly with which certain parts of *Brasenia peltata* are covered can not have escaped the attention of any one who is familiar with that member of the family of Nymphæaceæ. In my search for descriptions of the method of formation of this secretion, for such we must term the jelly-like mass, I have found but one brief statement in explanation of the development of it. This is by Asa Gray, who says "The jelly by which the stalks, etc., are thickly coated, I find to arise from the rapid formation and rupturing of successive epithelial cells, in the same way that mucilage is formed on the surface of animal mucous membranes."[1] This explanation is wholly inadequate, and I might also say entirely incorrect, as will become apparent further on.

Turning our attention first of all to the distribution of the jelly, it may be noticed in the plant represented on Plate III, fig. 1, that there is none of this coating substance to be found on the older parts of the creeping rhizome, and particularly not at such portions which were not of this year's growth, nor is any of the secretion observable on the petioles and blades of the older leaves still alive and vegetating. Three such leaves are represented by B, C, & A, in fig. I. On these, none of the jelly except perhaps slight traces of it, was perceptible to the touch. The next two leaves, D, & E, in fig. I, evidently younger and less well developed, show a thick film of jelly-like substance on the petioles, and this film extended also over the under surface of the leaf blades. The leaves of *Brasenia peltata* are alternate and elliptical in shape, and centrally peltate. The long diameter of each of the three older leaves above referred to as destitute of the coating of jelly was about 8 cm. The long diameter of each of the two leaves with the jelly-like coating on the petioles and under leaf-surfaces was 7 cm. and 6½ cm. respectively.

The leaves are involute in vernation, and the next younger leaf having not yet expanded, fig. I F shows the sides rolled inward, parallel to the longest diameter. This latter measured 5 cm. The entire leaf in this case seemed to be enveloped in a gelatinous sheath. On unrolling the sides I found, however, that the secretion originated

[1] A. Gray, Genera Floræ Americæ Boreali-Orientalis, Vol. I, p. 96, Note.

from the under leaf surface only. The upper leaf surface was almost completely hidden from view and consequently protected by means of the peculiar infolding of the leaf in the early stages of its development. The long diameter of the next younger leaf, with its sides similarly rolled in as in the case of the preceding one, measured 1 cm., fig. 1, G, and the thick gelatinous mass which coated it, extended also over the adjoining petioles and the punctum vegetationis. To the naked eye, this secretion appears as a transparent colorless jelly. Held up to the light it can be observed that numerous very fine hair-like processes extend into it from the plant. On magnification, these processes appear as represented in fig. II, A, B, C, D. It becomes at once apparent that these processes belong to the category of trichomes being outgrowths from the epidermis. In spite of the variety of form as represented in fig. II, these trichomes show a certain uniformity of structure. They consist in the main of one large cell, fig. II, X, and of a group of smaller cells uniting the large terminal cell with the epidermis below. Only two of this group of cells are shown in fig. II, A, Y. The trichomes are either unbranched, fig. II, A & B, or else they are branched or rather forked, fig. II, C & D. There cannot be the slightest doubt that these trichomes are the organs which are active in the secretion of the jelly, and they may therefore be termed glandular hairs. Since, at the time of collecting, it has been impossible for me to examine carefully the structure of these glandular hairs, the material was placed in 50 per cent. alcohol, and the observations which I here record were made entirely on alcohol material. The gelatinous coating suffered no perceptible change through this new medium.

From a leaf 1 cm. long, a portion of the epidermis of the under leaf surface was removed and examined. The glands were closely crowded, leaving no spaces between them. What I shall call the gland proper is represented in fig. II, A X, plus the group of smaller cells at the base already referred to, and two of which are represented by Y of fig. II, A. The gland of fig. II, A was of about the average size, and measured .205 mm. in height and .0369 mm. in width. Surrounding the gland proper will be noticed what I shall in distinction from this and for convenience merely term sheath, fig. II, A. S., which measured, in this particular case .2337 mm. x .0943 mm. The size of the sheaths varies considerably, and the explanation of this variation of size is found in the peculiar significance of these structures which will be dwelt upon immediately.

At the apex of the gland proper, a cap is noticeable, fig. II, A, Z, which was more highly refractive than the remainder of the cell wall. Directly below it the protoplasm seemed more dense, the protoplasm itself was yellow or brownish, granular and in part showed reticulations. Since I did not examine fresh material, I cannot, at present, say how far the protoplasm had been affected or altered in appearance by the alcohol.

The outer envelope or portion which I have for want of a better term called "sheath," is delicately walled, sometimes closed at the top, fig. II, A, and sometimes open, fig. II, B, C, D. The wall is transparent—almost colorless. This sheath, in all probability, represents the "epithelial cells" of Gray, but instead of being epithelial cells rapidly formed and ruptured, the observation of the method of development of these sheaths indicates a totally different explanation regarding their true nature. The method of secretion witnessed in glandular hairs is generally as follows: "The secretion regularly occurs first at the apex and spreads from there, lifting off the thin cuticle in shape of a bladder whose contents are then filled with the secretion."[1] Regarding fig. VI, where a sheath is just beginning to be formed, S″, and where another has already attained a considerable size, S′, there can be little doubt of the fact that the method of secretion in case of the glandular hairs of *Brasenia peltata* is entirely in accordance with that observed in glandular hairs generally. The sheath then is nothing more nor less than the cuticle lifted off by the secretion. The cuticle, as will be seen on comparison of the figures, is capable of growing or becoming stretched to a remarkable extent; this may be especially well seen in fig. VI and fig. VIII, both glands being taken from near the vegetative point where secretion seemed most active. The cuticle finally becomes broken, indistinct, and eventually seems to dissolve, as indicated in fig. II, C & D. A peculiar rupture of the cuticle witnessed in a few cases is shown in Fig. II, B. This was perhaps caused by some external agency, since, usually, the sheath seems to become indistinct rather gradually instead of a portion breaking off with a smooth edge.

According to Hanstein, the cuticle of glandular hairs in case of unopened leaf-buds after rupture is often regenerated, and the formation of new secretion begins.[2] This process is particularly evident

[1] Julius Sachs, Vorlesungen über Pflanzen Physiologie, Leipzig, 1887, p. 195.
[2] DeBary, Vergleichende Anatomie, Leipzig, 1877, p. 104.

in case of the glandular hairs of *Brasenia peltata*, especially so in hairs from near the vegetative point. On these successive sheaths may be frequently seen, as in fig. VI, S′ & S″, the next one appearing before the preceding one is dissolved. Fig. VII represents the apices of three such sheaths, the innermost always being the one last formed.

In accordance also with observations on similar organs of other plants, the secretion and secreting organs are most thick on the youngest and most tender parts as already described and represented in fig. I. The activity of the hairs evidently decreases from the punctum vegetationis backward, and ceases entirely on the older fully-developed parts. The hairs, although they cannot dry up in the manner usually to be observed on land plants, seem to die off and finally disappear, as indicated in fig. IV, a cross section of an older portion of the rhizome which no longer possessed any or, perhaps, slight traces of the gelatinous coating. Fig. V represents a surface view of the epidermis taken from about the same point as the cross section represented in fig. IV. In fig. V the places where the glandular hairs had once been active, are represented by H.

Fig. III, on the other hand, shows the great quantity of glands which beset a petiole which is thickly coated with jelly, and the more closely the vegetative point is approached, the more closely the glands are packed together, in fact, as has been stated before, at the points of greatest activity they are crowded to such an extent as to leave no spaces between them.

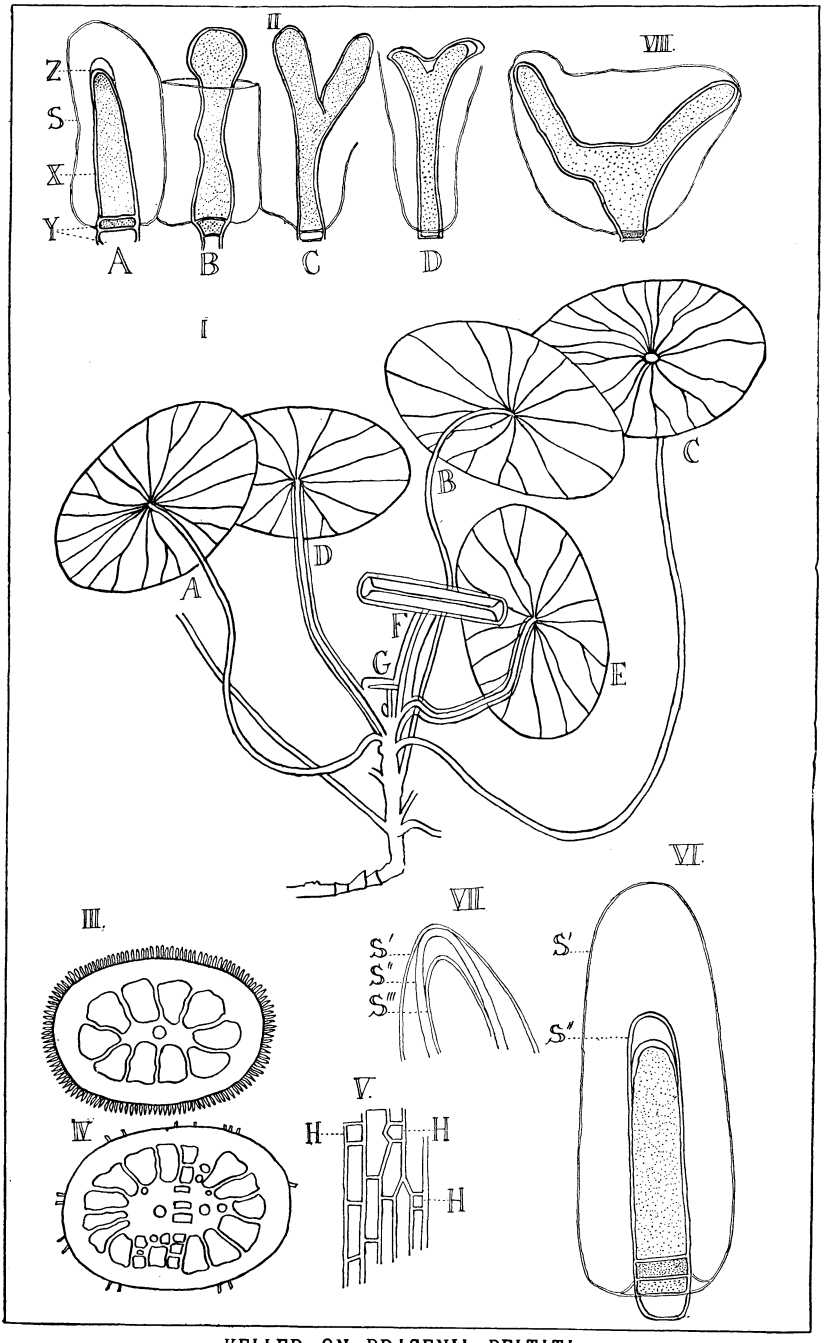
The glandular hairs of *Brasenia peltata* are then, as plant hairs are very apt to be, transitory organs, disappearing in the course of the development of the part which produces them. In function they are no doubt comparable to the "Colleters" of Hanstein.[1] This name Hanstein applies to the more massive trichomes which are found on the epidermis of leaves while still in the bud, and secreting during that stage different substances, such as gum or gum and resin, and by this means causing the parts to adhere to each other and protecting them from unfavorable external agencies. This active secretion must have been noticed by every one who has ever observed the opening of the buds of the horse-chestnut, poplar, etc. It may also be seen in the case of *Salvia*, *Polygonum*, *Helianthus* and other herbaceous plants.

[1] DeBary, Vergleichende Anatomie, Leipzig, 1877, p. 104.

It is interesting to find in *Brasenia peltata*, a member of the water-lily family and living therefore as an aquatic under entirely different conditions, similar means of protection for the younger parts as observed in the case of the terrestrial plants just referred to.

Although the chemical composition of the substances secreted by means of the "Colleters" varies considerably in different land plants, Hanstein applies the name "Blastocolla" indiscriminately to the product. There is no reason why this name should not also apply to the gelatinous coating found on the younger organs of *Brasenia peltata*. It may be expected that a plant surrounded by air requires totally different means of protection from one whose surrounding medium is water, and it may be taken for granted that the gelatinous coating of *Brasenia peltata* is one peculiarly adapted to the conditions in which that plant lives. At present, it is impossible for me to state the chemical composition of this substance. The only point which I can state with certainty is that the principal constituent of the secretion is water, which fact indicates that the secretion is one of those plant products which are capable of imbibing great quantities of water. It must be remembered that in water plants the principal water-conducting tissue, the xylem of the fibro-vascular bundles, is usually reduced to a more or less extent. In case of *Brasenia peltata*, I notice that this reduction is carried to an extreme degree, the xylem being entirely obliterated in the leaf petioles. There is, therefore, in this plant, no tissue particularly adapted to the rapid transportation of great quantities of water. The question naturally arises, how, under the circumstances here prevailing, in a plant entirely surrounded by water, containing within no xylem or water-conducting tissue, par excellence, is this imbibition process accomplished? The determination of this matter is, as I believe, of considerable importance, and requires a most critical observation. Two methods naturally suggest themselves: the secretion may draw the water from within, the water would then have to be taken in at other points of the surface of the different parts of the plant, and transferred from there to the glandular hairs; or the secretion may draw the water, or a part of it, directly from the outside. This latter, under the circumstances, seems to me the most probable explanation of the phenomena here witnessed. The question must, however, for the present, remain an open one. So far as I know, the imbibition of water from the outside by means of glandular hairs, has nowhere, as yet, been observed. Should the method

of secretion here suggested as probable for the glandular hairs of *Brasenia peltata* in truth prevail, I believe that this plant would prove most valuable in adding to our knowledge of the processes of secretion as observed in the vegetable kingdom.



KELLER ON BRASENIA PELTATA.